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**COLD STORAGE, FREEZING FACILITIES
AND TRANSPORT EQUIPMENT FOR FROZEN FOOD**

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COLD STORAGE, FREEZING FACILITIES AND TRANSPORT EQUIPMENT FOR FROZEN FOOD

By Per-Oskar Persson

Preservation of food by means of freezing has been well known for many years and already 1876 the first transport of frozen food from USA to Europe was done.

The first cold stores for frozen food were built in the late 18th century. These stores were only used for storage of meat and fish in bulk. The frozen food industry as we know it today with a large variety of products more or less ready for the table is rather young. USA has been the pioneer country, but even there the industry is not more than about 20 years old.

The consumption of frozen food in USA is now about 20 kg per capita. Sweden as the second country in the world regarding frozen food consumption had 1961 only 3,5 kg per capita. The frozen food industry here started immediately after the second world war and has grown rapidly. Below are some figures showing the rapid increase in consumption of frozen food (excluding ice cream).

<u>Year</u>	<u>Tons</u>	<u>kg/capita</u>
1951	1,500	0.2
1956	10,000	1.4
1961	26,000	3.5

During the same period of time naturally the cold storage capacity has been increased accordingly.

Possible storage times

Preservation by freezing is until now the best known method for most foods. If frozen in a proper way and stored at sufficient low temperature very long storage times can be achieved. In the figure below is indicated how long the storage time can be for different products stored at different temperatures. This time is often mentioned as the "High Quality Life" of the product, which means that also after this time the quality is only very little below the initial quality.

Figure 1.

Surplus to be frozen

It is obvious that with a storage temperature of -30°C (-20°F) meat can be kept for one year or more and fish in general for half a year without considerable change in quality. For countries with a short period of fishing harvesting or slaughtering the most important benefits can be obtained by freezing and storing of the surplus during these periods for consumption during the rest of the year. In the case of vegetables and fruits the quick freezing industry also allows the canning industry to produce at a steady rate and to utilize their production facilities throughout the year.

Thanks to the possibility of freezing it has been possible to increase the production of vegetables in many countries due to the increase in consumption period and consumption area.

Freezing for export

In some countries may e.g. the fishing industry give more than the local consumption can take or it should anyhow be possible to develop a fishing industry if the market was available. If the product as soon as possible after catching can be frozen one can obtain a high quality and good prices can be expected. The frozen product can then be sold in other parts of the country or exported to countries where a higher price is paid.

In other countries the meat industry might have surplus, which through proper freezing can be taken care of and sold to other areas. The distance for transport is almost unlimited and the quality when the product arrives to the consumer is almost as good as for the fresh product providing the freezing has been done properly and the cold chain never broken.

Ice cream and frozen foods

In many countries where the standard of living still is very low you might find that there is a great deal of ice cream sold. That means in fact that some sort of cold chain slowly is on the way to build up. Even if frozen foods generally are looked upon as convenient food and supposed to be rather expensive it seems quite likely that frozen foods, such as fish, can come to be marketed sooner than expected. The frozen food can to some extent use the same distribution system as the ice cream. This gives an increase in volume and gives better possibilities for the frozen food industry to grow.

Freezing facilities

In order to obtain a good result when freezing foods this should be done in special freezing equipment and not just by placing the merchandise in a cold store. The freezing shall be done as quick as possible for best quality. When a product is really quick frozen the ice crystals formed during the freezing will be very small and make very little damage to the internal texture of the merchandise. If on the other hand the product is slow frozen the ice crystals get very big and thus disturb the internal structure of the product.

It is also obvious that freezing should be avoided in the store as this will influence very badly on the storage temperature.

Freezing tunnels

These consist of cabinets of varying size with cooling coils and fans which force refrigerated air to circulate round the product to be frozen. The temperature of the forced air is -30 to -40°C (-20 to -40°F). The blast tunnel freezer is the most universally used equipment for freezing all types of products including carcass and cut meat, poultry, fish, butter and vegetables. The blast freezers can be made in almost any size. A disadvantage of this equipment is that due to the fan horsepower used for the air circulation and the low temperature of the cooling coils the cost of refrigeration will be relatively high. On the other hand the universality gives the best change for many operation hours per year, which reduce the capital cost per ton of frozen product.

For most new installations, where it is not quite clear how the market will develop, the installation of good freezing tunnels is recommended.

Plate frosters

Here the cooling surfaces take the form of 10 to 20 usually horizontal plates between which the product is placed. During the operation the plates are pressed tightly against the product in order to obtain best possible heat transfer.

The plate froster offers a very rapid and economical means of freezing products with good heat conductivity and providing they are in sufficiently thin packages. The plate froster is mainly utilized for fish products in blocks or packages. Sometimes it is also used for vegetables.

Most of the plate frosters now on the market are hand-operated. That means the product is placed on trays when transported to and from the freezer. They can also be fully automatic.

Immersion freezers

The freezing medium in this equipment is a brine solution into which the tightly packed product is immersed. This gives the same good heat transfer conditions as with plate frosters although the products, for instance poultry, cannot be given the rectangular form required by this type of equipment. It requires, however, an extremely close control to ensure that packages are not damaged, enabling the liquid to contaminate the product.

The immersion freezer shall only be considered if there is a highly specialized production, which goes over most of the year, and the product can be packed suitable for immersion freezing.

Belt freezers

The belt freezer consists of a conveyor belt, usually in the form of a mesh belt, which passes the product through a blast freezing tunnel. Although the belt freezer is a fairly universal instrument the selection of products which the equipment can handle is limited.

Fluidized bed freezer

A quite recent development which promises great advantages is the fluidized bed freezer. This works on the principle of products being exposed to an upwardly directed air stream, each particle being separated and surrounded by air, completely free to move. The fluidizing stream of air being also the freezing medium creates an extremely good contact between air and product resulting in extremely efficient heat removal. The machine produces a truly free flowing product, and as the product is carried on air there is no mechanical conveyor in the machine. This type of freezer is recommended for most products being loose frozen, such as peas, beans, corn, berries and diced products. See figure 2.

Figure 2.

Cold stores

A cold store should be placed either in an important production area or in an important consumption area. In both cases it is essential that the cold store should be big enough to give a satisfactory economic result.

During the last few years a definite tendency has developed to show a preference for storing in the production area. Storage in the consumption area will mean that there has to be transport from the cold store in the production area to the store in the consumption area with handling operations at both ends of the transport. When the goods are finally brought to the wholesaler or distribution store they will have to be handled once again. This latter handling operation will be saved entirely if the goods are kept in the production area until they can be sent direct to the distribution stores.

The cold stores should always be considered as a link in the distribution system. Therefore it should be designed to cooperate with an intensity of traffic quite unknown some years ago. The long delays and waiting time so often experienced at public and private cold stores is completely unacceptable in today's severe competition and there is a consequent demand for lower transport costs and quicker service. The latter calls for very careful planning of the traffic outside the cold store and a generous attitude towards space set aside for access roads, yards, loading bays, parking etc. to avoid congestion and allow the internal transport system of the store to work at a high and reasonably uniform level.

This need for spaciousness usually makes water-front locations rather an impossible proposition, since apart from the fact that large, unbroken stretches of land are normally non-existent in dock areas, the cost of such land will bring up the cost of the cold store to such a level that it becomes an important factor in the calculation of storage costs and rates. This applies particularly to one-storey buildings. Even if the store is situated on the water-front transport is usually necessary within the harbour area. The cost resulting from an extension in the length of this transport must be investigated carefully. Very often one will find that it is better to accept a somewhat longer transport in order to obtain suitable site with possibility for expansion.

Great simplicity is an essential factor when making the general layout for a cold store. Large unobstructed single span rooms, uncomplicated easy-to-pass entrance arrangements, straight gangways and easily accessible stacking areas. So far as possible all products should be laid on standard pallets.

All the handling inside the store should be done by fork lift trucks. For the transport into and out of the store it is often desirable to use electrical pedestrian trucks or conveyor systems. The height of the store should normally be enough to take 4 to 5 pallets in height.

Transport equipment

In order to obtain full benefit from quick freezing it is necessary to have a distribution organization, which can perform transport under sufficiently low temperatures. For the transport of bulk stored products refrigerated ships, refrigerated railway cars or big lorries are the type of equipment that can be considered.

In connection with distribution of ice cream or other types of frozen products ready to be sold in retailer's shop other types of transport equipment must also be available. As long as the sale is rather small different types of containers can be used but when the sale increases some sort of distribution vehicles with refrigeration system must be used.

Refrigerated ships

There are nowadays plenty of refrigerated ships sailing round the world. Most of these are, however, not equipped for transportation of whole pallet loads and therefore the loading and unloading must be done manually. Time for loading and unloading could be considerably shortened if palletization could be used, but on the other hand, in most cases this means a less good utilization of the storage space. This is a problem which the frozen food industry should like to see solved.

Railway waggons

There has been developed different types of mechanical refrigerated railway waggons during the last years. In some cases each waggon is individually cold by means of a compressor unit driven by a combustion engine. In other cases there is used refrigerated trains, where one waggon carries the refrigeration system for several waggons. The latter only suitable for long-distance transport of very large quantities.

In Sweden one organization has in cooperation with the Swedish State Railways developed different types of refrigerated railway cars during the last ten years. The latest design is shown on figure No.3. A description of the waggon is given in the text below the figure. The benefit of this waggon is that it never needs any refuelling or maintenance as long as it keeps running and the eutectic plates give always a certain amount of stand-by refrigeration capacity.

It is our experience in Sweden that transport of frozen food in railway cars is more economical than transport by road if the distance is 500 km equal to 320 miles or longer.

Figure 3

Road vehicles

For local distribution vehicles earlier dryice were used. Now normally eutectic plates and a compressor with electric motor mounted direct onto the vehicle are used. The eutectic plates charge over the night and give the vehicle capacity enough to operate the following day. Lately vehicles cold with liquid nitrogen are being used.

For big vehicles or trailers used for longer distances normally compressor units with combustion engines are used.

Containers

Smaller containers are almost always cold by dry ice. For larger containers eutectic plates in connection with an electric motor driven compressor unit also can be used.

Most of the containers are so small that only manually operation in and out can be considered. Lately has, however, been designed containers for as well railroad traffic as for transport on ship with a size suitable for taking 4 or 6 standard pallet loads.

Estimation of costs

Freezing facilities

Stationary freezers such as tunnels or plate frosters 50.000 \$ per ton/hour. Continuous freezers such as fluidized bed freezer 65.000 \$ per ton/hour. Above given figures refer to a capacity of 2 tons/hour. For smaller capacities the prices increase and for larger capacities a certain reduction can be expected.

Cold stores

Excluding the cost for land the following costs can serve as a guide:

Storage volume 40.000 m³ = 1.4 million cu.ft or more cost about 1 \$ per cu.ft.

Storage volume 10.000 m³ = 0.35 million cu.ft cost about 1.4 \$ per cu.ft.

Transport costs

As a rough indication of the cost for transport equipment for low temperature transport it can be said that such equipment are about 50% more expensive than equal equipment for non-refrigerated transport. Same comparison can also be used for the cost for transportation.

It is very important to try to get each transport as big as possible and the below mentioned figures from transport costs in Sweden is a good example. Costs are given in US \$ per kilogram (1 lbs. = 0.45 kg.).

Distance	Container		Railway waggon Capacity 10 tons (10.000 kg)
	Capacity 50 kg	Capacity 500 kg	
620 km 390 miles	.140	.054	.023
1610 km 1000 miles	.200	.088	.033

As you can see from this comparison the use of small containers can only be considered as something temporarily and also the use of the bigger containers is rather expensive.

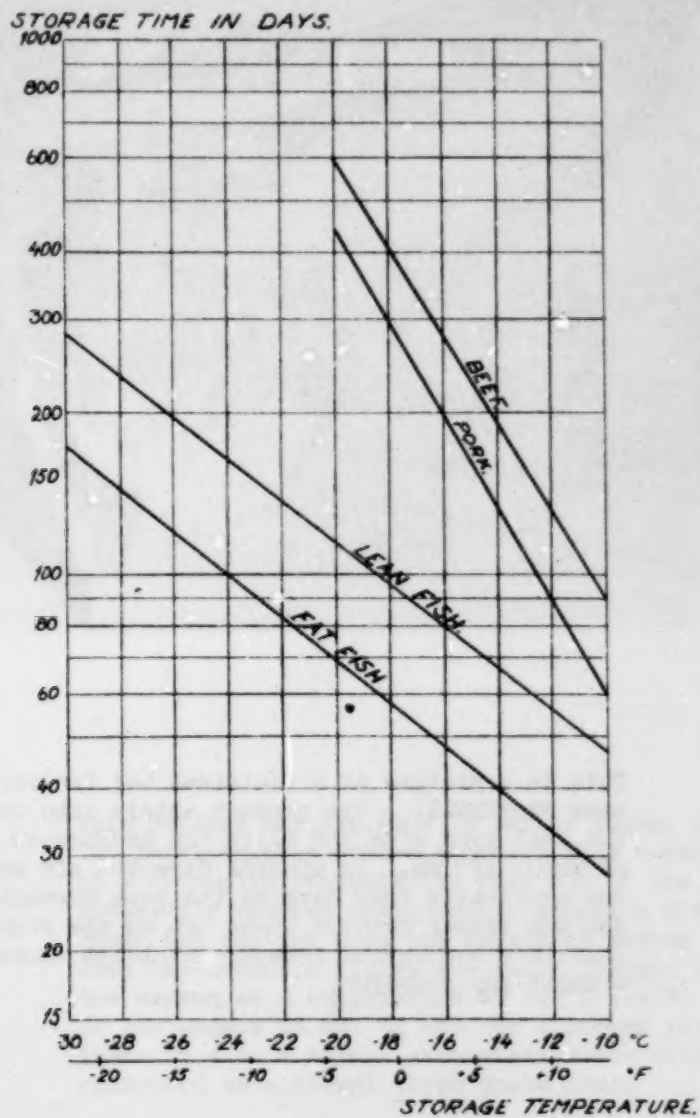


Figure 1:

Diagram giving longest recommended storage time for different merchandize stored at different temperatures.

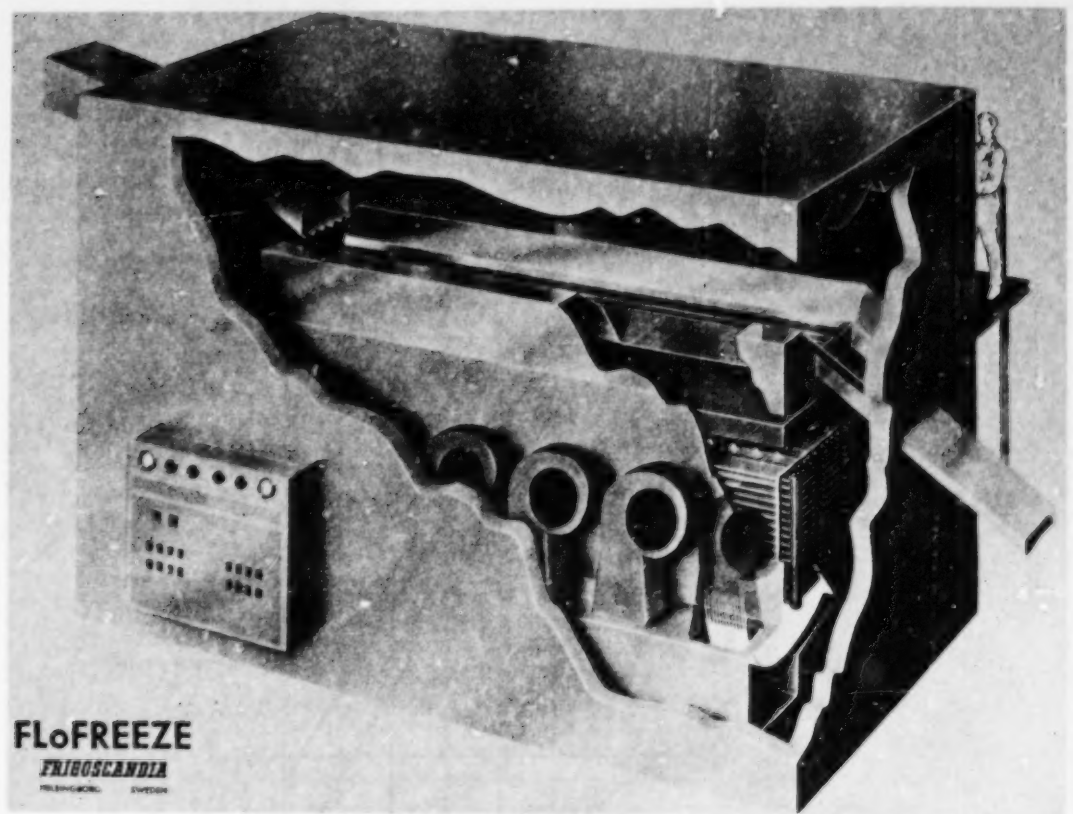


Figure 2:

This is a picture of a fluidized bed freezer with the trade name FloFREEZE. The product enters into the machine on the left hand side and fills the perforated tray to a height of about 175 mm. An upwards directed air stream through the perforated tray carries the peas through the freezer and the frozer product comes out on the right hand side. This is a continuous freezer for loose frozen products without any conveyor.



Figure 3:

This railway car can take 29 pallet loads, 1.25 x 0.8 m. The refrigeration system consists of a compressor driven by a hydraulic transmission from one of the axles. The compressor charges continuously eutectic plates positioned under the ceiling when the waggon is moving in a train. When the eutectic plates are fully charged they keep the waggon at a temperature of -20°C (-2°F) 48 hours. If the waggon is not in use for a longer period of time there is also a normal electrical motor which can be connected to a normal three phase line.

